by comparison with a calibrated one rather than to go back to absolute units of microwatts, angstroms, etc., as we have purposely done in the present case for each photoelectric cell.

The values for the amount of ozone above Mount Evans as determined by the four cells are in close agreement. Two of the cells indicated a value of about 0.20 cm. normal temperature and pressure, while the other two cells indicated about 0.22 cm. This is in close agreement with that of other observers (**1, 9**) for the same latitude and season of the year.

In conclusion, we wish to express our appreciation to W. W. Coblentz of the National Bureau of Standards, and to J. C. Stearns of the University of Denver, for helpful assistance, especially in arranging for the work, and for making available the use of Mount Evans Observatory. We wish also to express our thanks to K. W. Kemper of the Lincoln, Nebr., Weather office, who, at his own expense, assisted in the observational program on the top of Mount Evans.

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VARIATION IN SOLAR RADIATION INTENSITIES AT THE SURFACE OF THE EARTH IN THE UNITED STATES

By IRVING F. HAND

[Weather Bureau, Washington, D. C., May 1939]

This paper brings up to date two articles on the same subject published by Kimball in 1918 (**1**) and 1924 (**2**); however, the data here given are from stations in the United States only, whereas the previous papers included all available data for the entire globe.

The departures from normal were obtained by averaging the mean departures of each month's means for the three Weather Bureau radiation stations at Washington, D. C., Madison, Wis., and Lincoln, Nebr., and also for the Blue Hill station of Harvard University for the few years that this station has been in operation, and finally smoothing out the departures by the formula $(a+2b+c)/4$, where b is the average percentage departure for the month in question, and a and c are the average percentage departures for the preceding and following months, respectively. The smoothed percentages have been plotted in figure 1, and the same data tabulated in table 1.

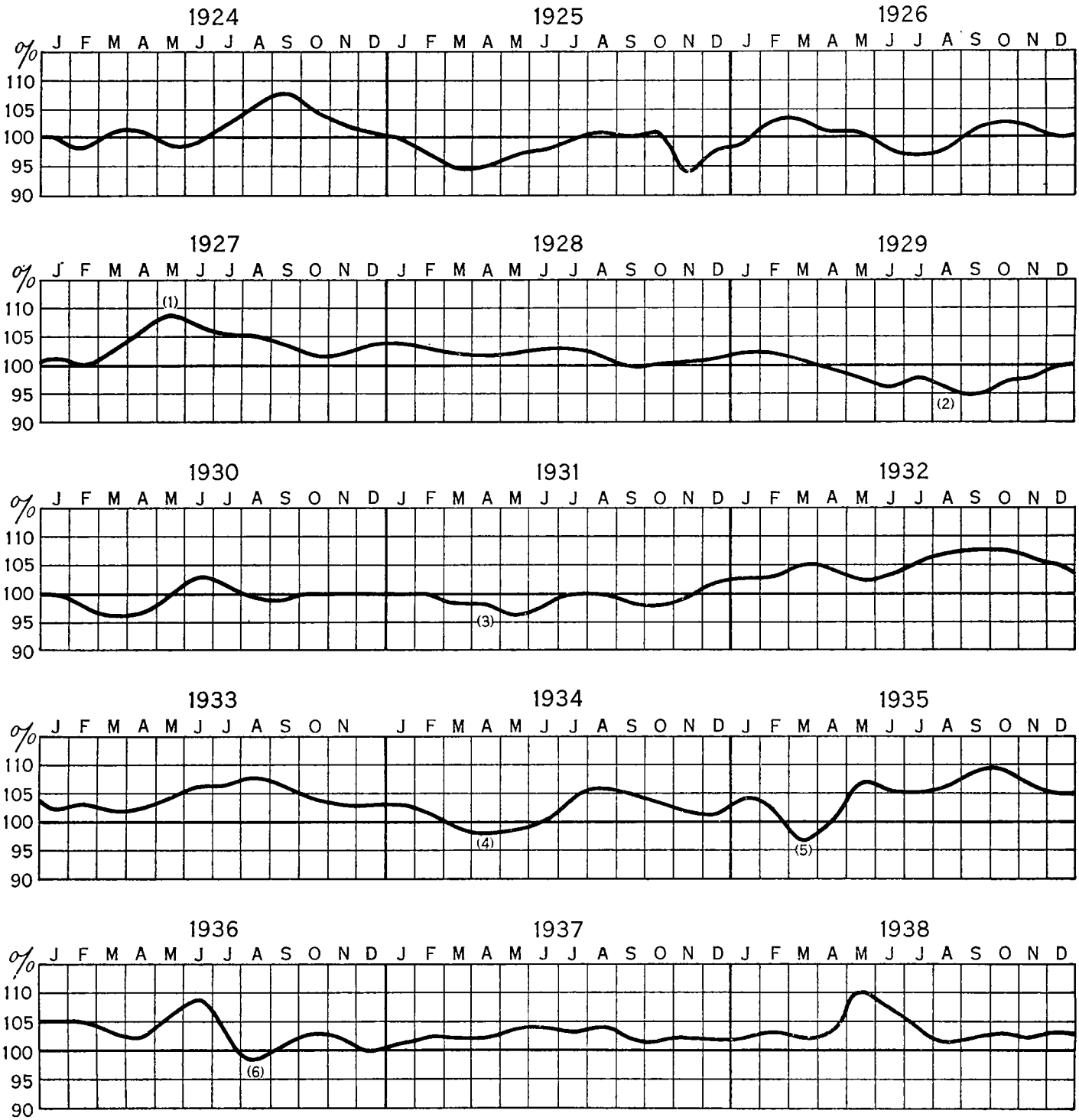
Owing to the small number of stations, local influences, such as duststorms, forest fires, irregular manufacturing activity, etc., are important factors in the fluctuations shown by the curve.

Although three major and several minor volcanic eruptions occurred during this 15-year period, no conclusive evidence appears that any of them depleted the solar energy received at the surface of the earth in the United States. The most violent explosive eruption during this period took place on the Isle Flores, Dutch East Indies, latitude 8° S. in August and September 1928, when an estimated 19½ million cubic meters of material were emitted. About the same amount of material was discharged from Quisapu volcano in Chile during its eruption in April 1929, but the proportion of lava-flow from this latter volcano was much greater than from the East Indies eruption. Although apparently neither eruption appreciably affected radiation receipt in the United States, it is interesting to note that the 1 or 2 months immediately following each explosion were those of minimum radiation receipt for the respective years. It is quite evident neither eruption carried large quantities of dust into the stratosphere; and in the case of the Chilean eruption we would expect very little dust to be transported across the equator from so southerly a latitude. The third violent eruption during the period occurred on the isle of Martinique in 1929 when Mount Pelée once again altered its skyline, this time without serious damage. That this eruption had little effect upon solar receipt is evident from the fact that solar radiation intensities began to increase immediately following the time of the volcanic activity.

As a matter of comparison with previous periods when volcanic activity did affect very appreciably solar radiation receipt at the earth's surface, we review briefly the effect of Krakatoa, Malay East Indies, latitude 7° S.; the explosion carried away the top of that mountain with such a detonation that it was heard for hundreds of miles, and with an emission of dust sufficient to deplete solar radiation receipt to but 84 percent of its normal. In 1902 the eruptions of Pelée on the island of Martinique, Santa Maria in Guatemala, and Colima in Mexico were followed almost immediately by an 18 percent diminution in intensity of radiation. The eruption of Katmai in Alaska on June 6, 1912, threw a tremendous amount of volcanic ash into the stratosphere which resulted in a decrease of 22 percent in radiation receipt, and a continuation of gradually lessening atmospheric contamination for 2 years.

In all three cases, owing to decreased solar heating of the earth, temperatures remained subnormal for at least a year following the individual explosions. With this in mind, attention may be drawn to the fact that temperatures in this country have been considerably above normal during the past 8 years, although this condition may have no relation to the increased radiation receipt.

The lack of volcanic eruptions of the type that throws dust into the stratosphere accounts for the general increase in radiation during the period 1924–38. It is far more difficult to explain why individual years show such a marked increase in radiation. However, there seems to



MONTHLY AVERAGES OF SOLAR RADIATION AT EARTH'S SURFACE, EXPRESSED AS PERCENTAGES OF THE MONTHLY NORMALS.

FIGURE 1.—Explanation of the reference numbers:
(1) Noon observations of May and June, 1927, were the highest ever recorded at Washington. (3)
(2) Forest fires. (4)
(3) Dust storms of unusual intensity. At Madison during the course of the observations on April 10, 1931, the radiation intensity at normal incidence was reduced from 1.20 gram calories at 9:30 a. m. with air mass 1.5, to 0.141 gram calories at 2:07 p. m. with air mass 1.45. (5)
(4) Dust storms also reduced intensities during 1934. At Lincoln, Nebr., radiation dropped to less than a quarter of a calorie. (6)
(5) Dust storms again depleted normal incidence radiation to such an extent that Madison reported the lowest total solar and sky record ever obtained during a single day. (7)
(6) Madison and Lincoln both reported considerable haze, dust and smoke. (8)

be little doubt that the large radiation receipt in 1932 was due in part, at least, to decreased manufacturing. In the January issue of the MONTHLY WEATHER REVIEW (60: 256) we find the following statement:

The outstanding feature for the year (1932) is the unprecedented large increase in radiation received on a horizontal surface from the sun at various places throughout the country. Without doubt the business depression was an important indirect factor in this increase. It will be noted that the large cities of New York and Chicago show the greatest plus departures. Dust and smoke records from these two cities show a marked diminution for the year, which would be expected as the amount of manufacturing had fallen off greatly during this period.

TABLE 1.—*Departures of normal incidence radiation in the United States*

Month	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
January	100	100	99	101	104	102	100	100	103	102	103	104	105	101	102
February	98	97	103	100	103	102	97	100	103	103	102	102	105	102	103
March	101	94	103	102	102	101	96	98	105	102	99	96	103	102	102
April	101	95	101	106	102	100	96	98	104	102	98	100	102	102	103
May	98	97	101	109	102	98	99	96	102	104	99	107	106	103	110
June	99	98	98	107	103	96	103	98	104	106	100	105	109	104	108
July	102	100	97	105	103	98	101	100	106	106	104	105	102	103	104
August	106	101	98	105	102	96	99	100	107	108	106	106	98	104	101
September	108	100	102	104	100	95	99	98	107.5	106	105	109	101	102	102
October	105	101	103	102	100	97	100	98	108	104	103	109	103	101	103
November	102	94	102	102	101	98	100	100	106	103	102	106	102	102	102
December	101	98	100	104	101	100	100	102	105	103	101	105	100	102	103
Year	+1.7	−2.1	+0.6	+3.9	−1.9	−1.4	−0.8	−1.0	+5.0	+4.1	+1.8	+4.5	+3.0	+2.3	+3.6

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TROPICAL DISTURBANCE OF SEPTEMBER 24–26, 1939, IN THE GULF OF MEXICO

By WILLIS E. HURD

[Weather Bureau, Washington, October 1939]

Only one tropical disturbance was reported during September. There was unsettled weather over the extreme northwestern part of the Caribbean Sea early on September 23. It is probable that this disturbed condition moved northwestward across the British Honduras and Yucatan during the 23d and early 24th under influence of a tropical disturbance that apparently developed about 100 miles east of Vera Cruz, Mexico, between September 20 and 22.

A report received by mail from the American steamer *Aztec* states that westerly winds of force 8 during squally weather were experienced from late on the 22d to early on the 24th in the southwestern part of the Gulf of Campeche and that there were heavy northwesterly swells.

At 7 p. m. (E. S. T.) of the 24th there was a fairly definite circulation, with slightly depressed barometer, near latitude 22° N., longitude 92° W., with winds of force 3–5 reported by ships within the area 20°–25° N., 90°–95° W.

During the 25th the central barometer had deepened somewhat and squally winds about the center showed local increases in force. At 7 a. m. of the 25th, in 26°05′ N., 91°45′ W., the Panamanian motorship *Cubahama* experienced a north-northeast gale of force 9, which is the highest wind velocity reported by a ship in connection with the depression. Her barometer, in a report later received by radio, was given as 1,005.8 millibars (29.70 inches). This reading, following the result of a later comparison at Mobile, was corrected to 1,003.7 millibars (29.64 inches), which is the lowest pressure reported for the disturbance.

On September 26, at 7 a. m. (E. S. T.), as the center was entering the coast, the American steamer *Roanoke*, at some distance to the southward, had a south-southwest wind of force 7, barometer 1,010.2 millibars (29.83 inches), in 27°56′ N., 89°00′ W. Quoting from the report of W. R. Stevens, forecaster on duty at the New Orleans office of the Weather Bureau:

> The disturbance moved inland south of New Orleans a short distance west of Grand Isle the morning of September 26, with only fresh winds near the center. A passing squall caused a southwest wind of 49 miles per hour at Pensacola, Fla., the morning of September 26 after the disturbance had moved inland.
> No report of damage or loss of life has been received.

Advisory warnings of the disturbance were issued by the Weather Bureau at New Orleans at frequent intervals from 9:30 a. m. (E. S. T.) of the 25th until 9:45 a. m. (E. S. T.) of the 26th. Chart XIII shows the path of the disturbance from the 24th to 26th, and the general situation on the morning of the 25th.